Backgrounder

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Nuclear Power Plant Fire Protection

Background

On March 22, 1975, a fire at the Browns Ferry Nuclear Power Plant fundamentally changed the concept of fire protection and associated regulatory requirements for U.S. nuclear power plants. Plant workers were fixing leaks in the cable spreading room outside the reactor building. The workers used a candle to test seals for air leaks into the reactor building. The polyurethane foam seal, however, was not fire-rated. The flame from the candle ignited both the seal and the electrical cables that passed through it.

By the time firefighters extinguished the fire, it had burned for almost 7 hours. More than 1600 electrical cables were affected, 628 of which were important to plant safety. The fire damaged electrical power, control systems, and instrumentation cables and impaired cooling systems for the reactor. Operators could not monitor the plant normally and had to perform emergency repairs on systems needed to shut the reactor down safely.

Investigations after the fire revealed deficiencies in the design of fire protection features at nuclear power plants and in the plant procedures for responding to a fire. Fire insurance companies, normally concerned with occupant safety and property protection, did not sufficiently consider nuclear safety issues. A fire in certain locations at a nuclear plant could cause redundant safety systems and components to fail, making it difficult to shut the reactor down safely.

Since the Browns Ferry incident, no fire at a U.S. commercial nuclear power plants has affected the safe operation of a reactor.

Fire Protection Regulations

After the Browns Ferry fire, the Nuclear Regulatory Commission revised its fire protection regulations to reduce the chances of a fire starting and the consequences should a fire occur. The regulations' bottom line is that each licensee must maintain the ability to shut down the reactor

safely in the event of a fire. The objectives of NRC's fire protection regulations ensure this ability by:

(1) minimizing the potential for fires and explosions;
(2) rapidly detecting, controlling, and extinguishing fires that do occur; and
(3) ensuring that operators can shut down the reactor safely despite a fire, and minimize the risk of significant radioactive releases to the environment.

Nuclear power plants today use redundant methods of fire protection to keep fires from damaging plant safety systems. Some of these methods include fire barriers such as insulation, fire detection systems, and fire suppression systems (such as sprinklers). If a required element of fire protection is not available, the licensee must compensate for it, often by placing dedicated personnel on a continuous fire watch. The NRC regularly inspects licensees' means of achieving and maintaining the safe shutdown of the reactor in the event of a fire.

Classic fire protection requirements help keep nuclear power plants safe by ensuring that systems for shutting the reactor down safely will survive a fire. These requirements, based on a set of possible serious fires, were developed before the staff or the industry had experience with probabilistic risk assessments (PRAs) for fires. Classic requirements also lack recent advances in performance-based analysis methods such as fire modeling.

Risk-informed regulations consider the safety significance of requirements and ensure the requirements' burden on licensees is appropriate to the safety level they provide. Performance-based regulations rely on a required outcome rather than requiring a specific process or technique.

The NRC approved one such risk-informed alternative in July 2004 that allows licensees to focus their fire protection activities on the areas of greatest risk. The agency enacted rule 50.48(c), which endorsed National Fire Protection Association (NFPA) Standard 805, "Performance-Based Standard for Fire Protection for Light-Water Reactor Electric Generating Plants, 2001 Edition," with some exceptions. To help licensees implement NFPA 805, NRC staff issued Regulatory Guide 1.205, "Risk-Informed, Performance-Based Fire Protection for Existing Light-Water Nuclear Power Plants[1]." The guide also endorsed the related Nuclear Energy Institute document NEI 04-02, "Guidance for Implementing a Risk-Informed, Performance-Based Fire Protection Program under 10 CFR 50.48(c)[2]."

Discussion

The NRC continues to oversee fire protection at nuclear power plants through inspection and oversight. The NRC also works with international codes and standards organizations and nuclear industry representatives to resolve the generic fire protection concerns discussed below.

Operator Manual Actions

Licensees are required to protect plant equipment necessary for safe shutdown using a combination of physical separation, barriers, and methods to detect and control or extinguish

fires. In certain cases at specific plants, the NRC has also reviewed and approved operator manual actions as another acceptable method to safely shut down the plant in the event of a fire. An example would be manually opening a valve to prevent it from closing improperly during a fire.

However, some licensees rely on operator manual actions that have not been reviewed and approved by the NRC, which led to a very large number of requests for exemptions to the regulations. NRC staff developed a proposed rule that would require the licensee to demonstrate the acceptability of any manual actions used to safely shut down a plant in the event of a fire. The key concept of that rule was that plant personnel should not face significant hazards in carrying out feasible, reliable manual actions to ensure safe shutdown of the plant. The rule's primary objective was improving efficiency by minimizing the number of exemption requests.

The public comment period for the proposed rule ended in May 2005, and industry comments indicated the NRC would receive a very large number of exemption requests under the new rule, primarily because of fire detection and suppression requirements. The staff concluded this would defeat the rule's objective, and therefore requested the proposed rule be withdrawn[3]. The Commission approved that request[4], and the staff continues to enforce existing rules through the Reactor Oversight Process.

Implementing Risk-Informed, Performance-Based Fire Protection

The Commission approved the 50.48(c) rule in May 2004, and published the rule in June. It took effect in July. The Commission also allowed the staff to use its discretion in enforcing certain fire protection issues for plants transitioning to the new rule. The enforcement discretion provided an incentive for licensees to adopt NFPA 805. Subsequently, by the end of April 2006, operators of 41 reactors had sent letters of intent indicating their commitment to adopt the voluntary standard.

Two nuclear stations, Oconee and Shearon Harris, volunteered to be pilot plants for the transition to NFPA 805. Consequently, the staff kicked off the pilot implementation in August 2005. The staff observed transition efforts at Duke Power in November 2005[5] and Progress Energy in March 2006[6]. More observations are planned at these plant sites. To aid plants in their transition to the new rule, NRC staff is working with industry to develop a Frequently Asked Questions program.

Risk Insights for Electrical Circuit Inspections

In the past, inspectors discovered electrical circuits at particular plants that, if damaged by fire, could prevent critical equipment from working properly. In March 2004, the NRC issued guidelines to allow inspectors to take relative risk into account when inspecting electrical circuits that are needed to shut the reactor down safely[78] . In addition, the staff issued a draft Generic Letter to clarify compliance expectations with respect to the issue of multiple false actuations in October 2005[9]. The staff plans to finalize the Generic Letter in August 2006. The NRC continues to work with regional inspectors and industry representatives to clarify and apply risk insights to regulatory requirements for analyzing circuits needed to shut down a reactor after a fire.

Significance Determination Process (SDP)

The NRC has revised its process for evaluating the significance of fire protection deficiencies found during inspections. This process is based on a simplified fire probabilistic risk assessment (PRA). NRC inspectors can easily use the SDP to obtain an assessment of the risk significance of a finding. The NRC has also developed quantitative fire hazards analysis methods, in NUREG-1805[10], for the fire protection significance determination process.

Hemyc Fire Barrier Qualification

Full-scale fire tests recently performed by the NRC revealed that Hemyc, a fire barrier system used to protect cables in electrical raceways in nuclear power plants, does not perform as designed. The outer covering of the barrier can shrink during a fire, opening joints in the material and potentially allowing the fire to damage cables inside. These results show that Hemyc does not serve as a fire barrier for the full hour required.

The agency has contacted the licensees of those 11 plants using Hemyc to inform them about the test results so that appropriate compensatory actions can be taken. Since the material is designed for use in areas with both fire detection and automatic fire suppression systems, the NRC remains assured that those plants' overall fire protection scheme will ensure safe shutdown of a reactor in case of fire. The NRC issued a generic letter in April 2006[11] to ensure that the affected licensees take appropriate corrective actions.

Source Documents

Documents related to fire protection are available on the NRC's Web site at: http://www.nrc.gov/reactors/operating/ops-experience/fire-protection/regs-guides-comm.html . The NRC's regulations for nuclear power plants can be found in Title 10 of the Code of Federal Regulations (10 CFR), available on the NRC's Web site. Fire protection regulations are detailed in Part 50.48 of 10 CFR and Appendices A and R to Part 50.

(Documents listed in endnotes are available on the NRC Web site by entering the relevant ML number at this address: http://adamswebsearch.nrc.gov/dologin.htm .)

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1. ML061100174

2. ML051430573

3. ML053350238

4. ML053350223

5. ML060240605

6. ML061530193

7. Regulatory Issue Summary 2004-03, “Risk-Informed Approach for Post-Fire Safe-Shutdown Circuit Inspections, Revision 1” ML042440791

8. Regulatory Issue Summary 2005-030, “Clarification of Post-Fire Safe-Shutdown Circuit Regulatory Requirements” ML053360069

9. ML053620142

10. ML043290075

11. ML053620142